bigQ - Annual highlights 2019

There is light at the end of the tunnel for optical quantum computing

At the core of quantum computers is *entanglement* – a quantum phenomenon that correlates properties of physical systems to an extent that cannot be explained by classical physics. Entanglement is essential for the number-crunching power of quantum computers that researchers across the world so eagerly strive to harness. However, it is also at the heart of all the challenges. *Why?* Because it is hard to preserve quantum states, in particular multi-partite entangled ones, and because 1,000s of well-behaved quantum bits – *qubits* – are required to enter the regime where quantum computers can outperform their classical predecessors. So far, prevailing superconducting technologies can only muster less than 100 flimsy qubits and only by keeping them at close to absolute zero temperature. A road less travelled, yet alluring, is that of optical quantum computing. Here, standard fiber optic technology can be used to form information-carrying photonic qubits in temporal segments of a laser beam. And everything can be done at room temperature! In 2019, bigQ walked down that road and managed to generate an entangled state of 30,000 optical qubits. Moreover, and very importantly, the qubits were woven together in a particular structure, namely that of a *2-dimensional cluster state* (Fig. 1), as required for universal quantum information processing. In other words, it is the fabric that optical quantum computers are made from.

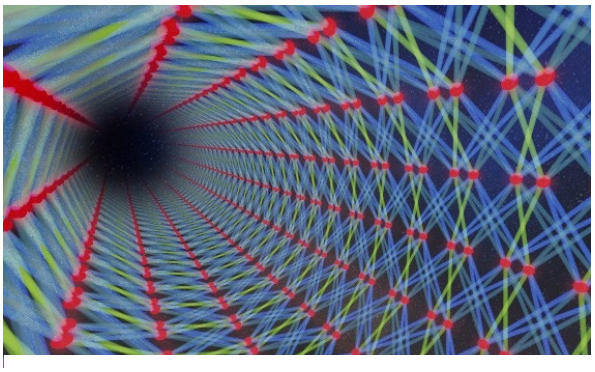

Figure 1: *Artistic rendering of the cylindrical 2-dimensional cluster state generated in bigQ.*

This work was published in *Science* in December 2019:
M.V. Larsen et. al. ***Deterministic generation of a two-dimensional cluster state,*** Science **366**, 369-372 (2019)

Building a Danish quantum technology community

As illustrated by the case above, the fundamental research carried out in bigQ is closely related to the development of potentially disruptive quantum technologies. Danish research generally has as strong position in the international quantum technology landscape, but nationally there is a need for building a vibrant quantum technology community that brings together stakeholders from academia, industry, funding bodies, and decision makers. bigQ actively contributes to this process through the center's leading role in the QuantumDTU network. In 2019, bigQ contributed significantly to a number of community building initiatives: On May 14, Nobel Laureate Prof. Haroche gave the first lecture in the series *QuantumDTU Distinguished Lectures*, aiming to inspire the community through lectures by esteemed international researchers. On June 13, the first Danish quantum technology Industry Day was hosted at DTU. The event brought together more than 100 stakeholders from academia and industry for a day of networking, knowledge-sharing, and a panel discussion with bigQ leader Prof. Andersen and research leaders from IBM Research and Thales (Fig. 2).

Figure 2: *Quantum community building events co-organised by bigQ during 2019.*